

A NUMERICAL STUDY OF A SMALL GROUP OF *ACROPORA* SPECIMENS
(SCLERACTINIA: ACROPORIDAE)

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ABSTRACT

A small group of museum (skeletal) specimens belonging to four recognised species of *Acropora* with suggested affinities was subjected to a simple taxonomic analysis, using an information theory model. The results suggested distinct species groupings, with growth-form in one case influencing subgroupings. Implications were taken on the role and suitability of the various morphological attributes.

The coral genus *Acropora* is highly speciated, but species limits, species affinities, and growth form variability are poorly understood. Although skeletal morphology is only one aspect of species characterisation in the Scleractinia (see Lang, 1972) it requires further understanding in this particular genus before most experimental methods of species differentiation could be applied. A study of this nature has been commenced on the species *A. squamosa* (Brook) and *A. hebes* (Dana) from the Great Barrier Reef, and it is hoped that numerical methods could be employed to examine attribute variation within the species. In order to examine possible ways in which morphological features might be quantified, a simple numerical study was carried out, using a selection of skeletal attributes.

MATERIAL

SPECIMENS: Twenty-three dried skeletal specimens from the registered collections of the Queensland Museum, most of them identified by J. W. Wells and mentioned in Stephenson and Wells, 1956, were used as the individuals in the study. The specimens belong to the four species *Acropora squamosa* (Brook), *A. hebes* (Dana) (both placed by Brook, 1893, in subgenus *Lepidocyathus*) and *A. corymbosa* (Lamarck), *A. surculosa* (Dana) (both placed by Brook, 1893, in *Polystachys*). Information on this material is given in Table 1.

In some of its growth forms *A. hebes* is difficult to distinguish from *A. squamosa* in the field, as was noted by Crossland (1952, p. 217). The radial corallite structure of *A. corymbosa* and *A. surculosa* has some similarities with *A. squamosa*, and some growth forms approach those of *A. squamosa*. No synonymization has been suggested between members of the group, and it was hoped that the species would separate easily, and that the influence of growth form could be seen. Attention was focused on *A. hebes* and *A. squamosa*, the other species being employed for comparative purposes. The single specimen of *A. surculosa* (the only one available) contributed little to the study.

TABLE 1: INDIVIDUALS INCLUDED IN THE STUDY.

Number	Qd Museum Registration	Identification	Identified by*	Locality	Microhabitat†
1	G2743	<i>A. squamosa</i>	S and W†	Low Isles	'tag missing'
2	G6612	<i>A. corymbosa</i>	C. Wallace	Tryon Reef	—
3	G2673	<i>A. hebes</i>	S and W†	Low Isles	'E. side, <i>Porites</i> pond'
4	G2663	<i>A. hebes</i>	S and W†	"	'traverse xi'
5	G2621	<i>A. corymbosa</i>	J. Wells	Heron Is.	'Reef flat'
6	G2623	<i>A. corymbosa</i>	S and W†	Low Isles	'Right up creek between mangroves, Traverse xxxvii'
7	G2754	<i>A. surculosa</i>	S and W†	"	'traverse xii'
8	G2664	<i>A. hebes</i>	S and W†	"	'W. of old <i>Tripneustes</i> spit, L.W.M.'
9	G2724	<i>A. squamosa</i>	S and W†	"	'traverse xii'
10	G2737	<i>A. squamosa</i>	S and W†	"	'Loc. xiv, below L.W.S.'
11	G2675	<i>A. hebes</i>	S and W†	"	—
12	G2674	<i>A. hebes</i>	S and W†	"	'traverse xxx sandy glade between mangroves, coral rich area'
13	G2626	<i>A. corymbosa</i>	S and W†	"	'traverse xii'
14	G2666	<i>A. hebes</i>	S and W†	"	'traverse xxxv, trickle zone from main mangrove outlet'
15	G2676	<i>A. hebes</i>	S and W†	"	'W. of old <i>Tripneustes</i> spit, L.W.M.'
16	G2739	<i>A. squamosa</i>	S and W†	"	'traverse xii'
17	G2671	<i>A. hebes</i>	S and W†	"	'L.W.M. Traverse xxv, trickle zone from main mangrove outlet on S. end of E. side'
18	G2740	<i>A. squamosa</i>	J. Wells	"	'traverse xii'
19	G2744	<i>A. squamosa</i>	J. Wells	Heron Is.	'Reef flat'
20	G2736	<i>A. squamosa</i>	J. Wells	"	'E. side anchorage very shallow water'
21	G2738	<i>A. squamosa</i>	S and W†	Fitzroy Is.	'Below M.L.W.'

*S and W refers to W. Stephenson and J. Wells.

†Mentioned in Stephenson and Wells, 1956.

‡Microhabitats as given on label by Stephenson and Wells, 1956 (see their map).

ATTRIBUTES: A list of 16 attributes measurable on the dried skeleton was devised. Attributes were chosen so as to give an even coverage of the various skeletal aspects: growth form, size, and corallite structure. The attributes, for this initial study, were expressed in unsophisticated terms, and all numerical measurements were an average of five scores. All attributes are listed in Table 2 (results of GROUPER).

TABLE 2: ATTRIBUTES EMPLOYED IN THE STUDY, AND THEIR RANKINGS IN THE GROUPER RESULTS.

Number	Attribute	Ranked contribution of the attribute to fusion number			
		38	39	40	41
	<i>Qualitative:</i>				
1	taper/non taper of final branch	1	5	8	13
2	occurrence/non occurrence of anastomosis	15	16	13	3
3	one/two cycles in radial corallites	14	13	9	16
4	one size/range of sizes in radial corallites	16	15	7	10
5	wide/narrow primary axial septa	7	7	15	14
6	one/two cycles in axial corallites	8	6	10	15
	<i>Numerical:</i>				
7	diameter of final branch	6	8	2	7
8	length of final branch	2	2	6	8
9	angle of final branching	12	12	5	1
10	axial corallite exertness	3	11	1	9
11	axial corallite width	4	3	4	5
12	maximum number of bifurcations before final branch	9	10	14	11
	<i>Disordered multistate:</i>				
13	growth form (3 states)	10	1	16	6
14	structure of undersurface (5 states)	5	14	3	4
15	shape of radial corallites (4 states)	13	9	11	2
16	degree of coenosteum development between radials (3 states)	11	4	12	12

PROGRAMMES: The sequence of programmes was chosen by M. Dale. It is now widely used for taxonomic studies in Australia, and available on the C.S.I.R.O. PDT 10 computer in Canberra. It runs as follows:

- (1) MULTBET: an agglomerative method of sorting, associating individuals or groups by the successive gains in information associated with fusions. Results are expressed in a dendrogram (see Lance and Williams, 1967).
- (2) GROUPER: analyses the major groupings in the MULTBET dendrogram, in terms of the ranked contributions of the various attributes.
- (3) GOWER: a principal coordinates analysis (see Gower, 1966).

RESULTS

(1) MULTBET: A dendrogram expressing the results of the MULTBET programme is shown in Figure 1. The three largest groupings (fusions 37, 38, 39) are a basically

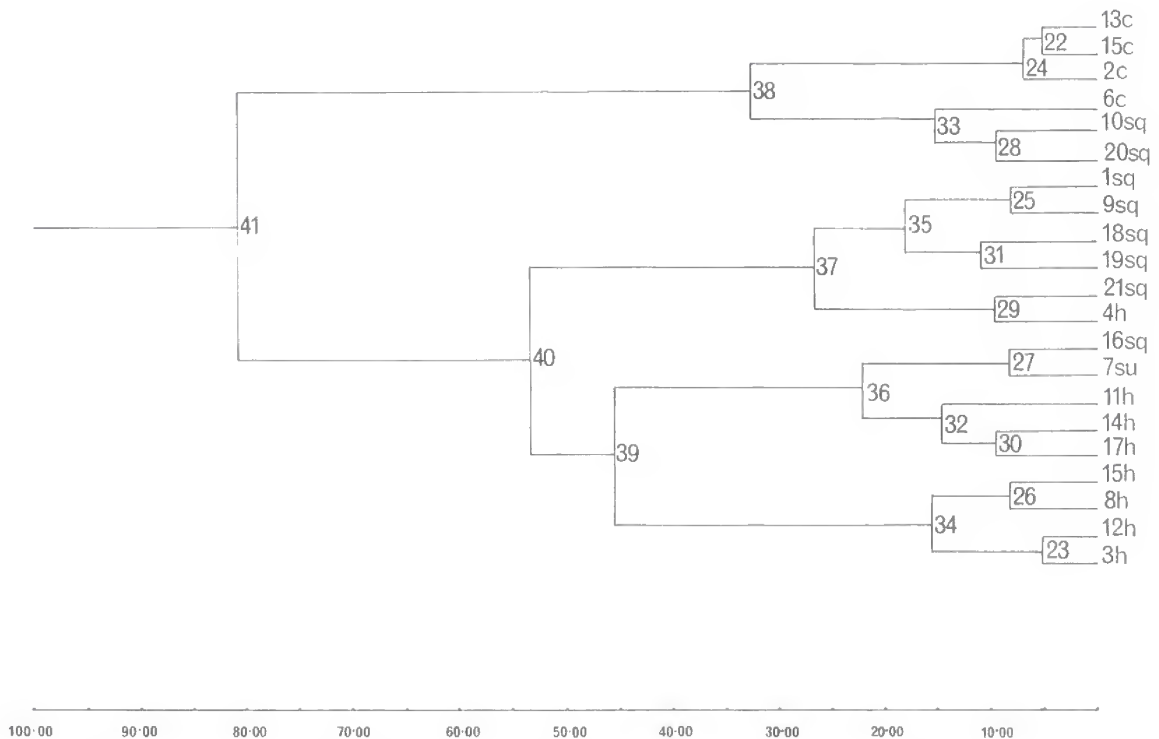


FIG. 1: Dendrogram of results of Multbet programme. Numbers at junctions indicate order of fusion. Scale represents coefficient (information gain).

c = *Acropora corymbosa*

h = *A. hebes*

sq = *A. squamosa*

su = *A. surculosa*

A. corymbosa, a basically *A. squamosa*, and a basically *A. hebes* group. The *A. hebes* group is composed of two sub-groups (36, 34). Group 34 has four members, all from inner reef flat areas, and all with similar appearance (low, open-arborescent, sprawling). The *A. hebes* specimens in group 36 are from outer flat regions; all have a 'simulated corymbose' appearance.

(2) GROUPE: Table 2 lists the attributes used and their ranked contributions to the four major groupings. An overall ranking shows that the attributes, as used, showed the following order of importance in forming the overall classification:

1. axial corallite width.
2. length of final branch.
3. diameter of final branch.
4. axial corallite exertness.
5. structure of undersurface.
6. taper of final branch.
7. angle of final branching.
8. general growth form.
9. shape of radial corallites.
10. one/two cycles in axial corallites.

11. degree of coenosteum development between radials.
12. wide/narrow primary axial septa.
13. maximum number of bifurcations before final branch.
14. occurrence/non-occurrence of anastomosis.
15. one size/range of sizes in radial corallites.
16. one/two cycles in radial corallites.

(3) GOWER: The results of the GOWER programme are expressed as two-dimensional ordinations (Fig. 2). The principle coordinates along the first and second, then the first and third vectors are plotted, and in each case a dotted line is drawn between each point and its nearest neighbour. When this is done in the 1/2 vector diagram, five interconnected 'groups' are formed: an *A. corymbosa* group, an *A. squamosa* (+ *A. surculosa*) group, a second *A. squamosa* group of individuals 10 and 20, an *A. hebes* 'corymbose' group, and an *A. hebes* 'arborescent' group. It will easily be seen that these groups are basically similar to those formed in sequence by the agglomerative process; when all three vectors are combined this similarity is emphasised.

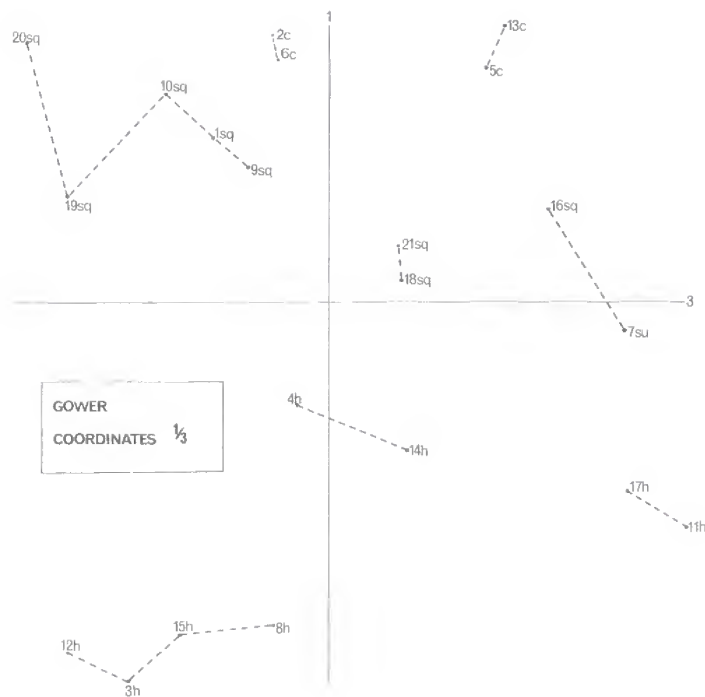
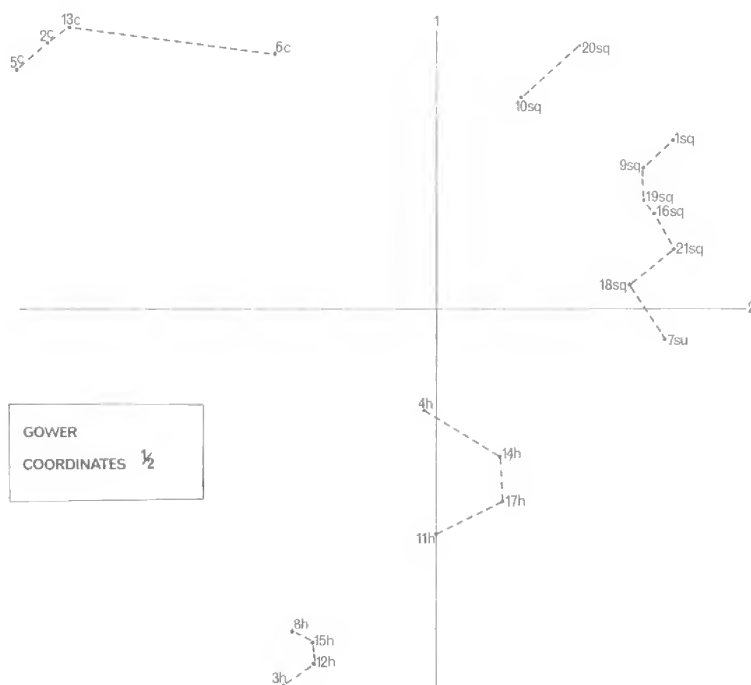
DISCUSSION

With the exception of the *A. surculosa* specimen, which did not have the opportunity to group with its own species, most of the specimens fell roughly into the species groupings they had previously been allotted by identification methods. This was expected, as most of the attributes used are taken into consideration for species definition. The programmes were run for the heuristic purpose of developing better definition of attributes for the study of morphological variation with location. With this in mind it is the Grouper results which are given most consideration. Grouper is employed only on the MULTBET process. The GOWER results are taken as a confirmation of the MULTBET groupings, as it is presumed that any anomalies in MULTBET would be contradicted in the GOWER results.

When the overall ranking of attribute 'importance' is considered, the highest ranked attributes are seen to describe dimensions: axial corallite width, length of final branch, diameter of final branch, and axial corallite exertness. The next four rankings describe corallum growth form: structure of undersurface, taper of final branch, angle of final branching, and general growth form. These were also the attributes which were the easiest to define and measure. They would probably be used in a similar form in a future study.

With two exceptions, the remaining attributes presented some difficulties of definition, and were probably expressed in an over-simplified form. The two exceptions were radial corallite structure and the possession of uniform as opposed to varying radial corallite size. These are attributes of 'key' importance in separating the three species, and for this reason they were simply expressed in disordered multistate and qualitative terms, respectively. It is evident that they are not, as used, sensitive to the sort of variation that might be expected between populations and between growth forms. In a future study they would be expressed as measurements, although this will provide difficulties, as it will be the dimensions of essentially different shapes which are measured.

The only Grouper programme in which some attributes describing the corallites rather than the corallum are given high ranking is that from fusion 39, which unites two



essentially *A. hebes* sub-groups. In this case it is possible to give a definition of each sub-group in terms of the highest ranked attributes: Group 36 'of corymbose growth-form, short terete branchlets, crowded radial corallites, axial corallites with one cycle of well developed septa', and group 34 'of low arborescent growth form, tapering branchlets, radials more sparsely distributed, axial corallites with two cycles of poorly developed septa'.

The most obvious omission from the above definitions is a description of radial corallite differences. This should be rectified by a change in radial corallite definition as previously discussed. Septal cycle definitions for both axial and radial corallites would probably be better expressed as counts of the number of secondary septa, rather than as presence/absence of a secondary cycle.

CONCLUSIONS

It appears from the GROUPE results, that attributes expressed in binary terms will not prove very useful in a study at this low taxonomic level. It is also apparent that the structure and dimensions of the radial corallites need to be better quantified for them to play any part in the numerical classification, and in turn, for their effect on the classification to be examined. The results suggest that, if these changes are followed, the MULTBET-GOWER-GROUPE programme can be employed to sort specimens into groups, whose attribute-sets can be easily seen. When specimens are accompanied by detailed locality data, the possibility that groups so formed are population or zonation groups can be examined.

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FIG. 2: First three vectors from the Gower ordination process. A dotted line has been drawn between each point and its nearest neighbour.

c = *Acropora corymbosa* h = *A. hebes* sq = *A. squamosa* su = *A. surculosa*